

SCIENCE TASK ANNOTATION

ANNOTATION KEY

EQUITY

Supporting a wide range of diverse students.

SCENARIOS

Information provided to elicit performances.

SEPs

Opportunities to demonstrate science and engineering practices.

DCIs

Opportunities to demonstrate understanding of disciplinary core ideas.

CCCs

Opportunities to demonstrate understanding of crosscutting concepts.

SENSE-MAKING

Opportunities for reasoning about phenomena and problems.

ASSESSMENT

PURPOSE
Highlights how the task features connect to intended assessment use.

LESSON 7: HOW CAN SO MANY DIFFERENT SOUNDS BE COMING FROM THE NEEDLE AND THE RECORD WHEN YOU SPIN IT?

(INCLUDES EMBEDDED ASSESSMENT #2)

Middle School Unit: How Can We Sense So Many Different Sounds From a Distance?

Previous Lesson...Where we have been: Students drew on experiences with instruments and connected those to what they noticed in playing a song from small music boxes to argue that changing the length of an object would provide useful data on how vibrations at the sound source compare due to changes in pitch. Students collected data with the motion sensor to produce graphs that helped them notice new patterns of change related to the amount of time a vibration takes (its frequency) for sound sources that produce different pitch sounds (different notes).



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LESSON 7: HOW CAN SO MANY DIFFERENT SOUNDS BE COMING FROM THE NEEDLE AND THE RECORD WHEN YOU SPIN IT?

Middle School Unit: How Can We Sense So Many Different Sounds From a Distance?



This Lesson...What we are doing now: This lesson marks the end of Bend 1. You will help students connect three ideas together to go back and explain the anchoring phenomenon in further depth than they last did in Lesson 3. They will revisit one of the two previous data sources (video of song playing or the homemade needle and record) and will also simulate the interaction of the needle and the record surface using manipulatives. They will use these results to make claims for how the different patterns in the grooves could force the needle to deform a different distance and vibrate at different frequencies. Last of all, students will take an embedded individual assessment applying what they learned to explain new phenomena.

Lesson Question	Phenomena	Lesson Performance Expectation(s)
<p>L7: How can so many different sounds be coming from the needle and the record when you spin it? (includes embedded assessment #2)</p> <p>3 periods: (40 min each)</p>  <p>Building toward ↓ NGSS PEs: 1-PS4-1 4-PS4-1 MS-PS4-1</p>	<p>The anchoring phenomenon from Lesson 1</p> <p>A harp player in a video is plucking strings of different lengths as different sounds are heard coming from it.</p> <p>Optional: A wooden stirrer vibrates at different frequencies when its thickness is increased (doubled, tripled) and it is plucked.</p> <p>Stretching the neck of a balloon as it deflates affects the pitch of the sound that is produced.</p> 	<p>Argue from evidence by respectfully providing and receiving critiques about each other's claims, explanations, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail <i>to help explain how the variation in the patterns in the structure of the grooves on the record could force (cause) the needle to vibrate at different frequencies and with different amplitudes, resulting in it (effect) producing different sounds as you spin it.</i></p> <p><i>The embedded assessment #1 also targets a subset of the Lesson Performance Expectations from lessons 2 through 6.</i></p>

The instructional materials provide an interesting question that can sustain a 3-period lesson and can elicit grade-appropriate evidence of a number of different NGSS dimensions and, with substantial support in helping students make connections between the two, could provide insight into the anchoring phenomenon.

Because many students will not have experience with records and will not know why this phenomenon could be interesting, the task provides a guided brainstorm for students so they can discover why the phenomenon is surprising.

CONNECTION TO ASSESSMENT PURPOSE

EQUITY

The connection between the Lesson Performance Expectations and the NGSS Performance Expectation they are building toward is not laid out clearly. This lesson sets out to bring together an ambitious number of different SEPs & CCCs together with the core idea. It is challenging to provide evidence of students' progress with so many dimensions in one task. In fact, we see that students MIGHT touch on any or all of these dimensions in their responses, but they are not necessarily elicited and we don't know that we'll get evidence of them.

DCIs

SEPs

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What We Figured Out (CCCs & DCIs), New Questions and Next Steps

We wondered how these ideas we had developed so far might be used to explain how the needle produces so many different sounds.

We had some predictions that the variation in the patterns in the bumps or shape of the grooves on the record might be forcing the needle to vibrate at different frequencies and amplitudes, so we wanted to look at one of these two data sources we had seen before to see if we could see evidence of this: (1) the Michael Jackson video of the closeup of the needle on the record, and (2) our own homemade needle and record from the anchoring phenomenon.

Based on our observations of one of these data sources and our ideas we developed so far, we argued from evidence that

- high notes and low notes, quiet sounds and loud sounds were produced at different points along the record surface;
- the needle must be vibrating at a greater frequency if it is producing higher pitch notes and lower frequency if it is producing lower pitch notes; and
- the needle must be vibrating with a greater amplitude if it is producing a louder sound and a lesser amplitude if it producing a quieter sound.

But it seemed really hard to clearly see changes in frequency and amplitude in the vibrations of the needle as when we had the motion detector. We decided a large scale object (like a ruler, a straw, or a coffee stirrer) could help us visualize this predicted motion of the needle as it interacted with the patterns in the grooves when the record was spun.

We used a coffee stirrer and a photograph of the record surface grooves to simulate its motion as they interacted with each other.

We argued from evidence from the results of the previous simulation that, “Different sections of grooves could force the needle to deform different distances, and therefore move back and forth at different amplitudes as the record is spun.”

We updated our Incremental Model Tracker to include these ideas:

- Different patterns in the grooves can force the needle to deform different distances, and therefore move back and forth at different amplitudes as the record is spun.
- Different patterns in the grooves can force the needle to move or bend back and forth at different frequencies as the record is spun.

In light of the claims we had made so far, we predicted how spinning the record faster would affect the sounds produced, and we tested our prediction.

We individually assessed our understanding by applying the ideas we figured out to explain a new phenomenon (someone playing a harp) and analyzed new sets of vibration-related data in our Lesson 7 — Assessment # 1.

Next steps (Optional): After this assessment, we selected one of three enrichment activities that we were most interested in finding out more about. One, an interactive reading, was related to how humans produce sounds with their voices. The other two, investigations to collect data on at home, were about how changing the thickness or tightness of an object affects how frequently the object vibrates after being struck or plucked.

Next Lesson...Where we are going: The next lesson marks the start of Bend 2. Students will look at another phenomenon (a truck stereo playing music very loudly) and a surprising effect: the movement of windows in a building across a parking lot. This phenomenon will problematize something about their model that they took for granted—namely what the thing was that was traveling from the sound source to our ears, detectors, or to any object far away. This will help motivate future lessons around questions regarding what is happening with the air (or any material) that sound travels through and what exactly sound is.

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GETTING READY: MATERIALS PREPARATION

Materials for Each Student

- *Lesson 7 Student Activity Sheets*
- *Lesson 7 Record Surface Student Handout* (1)
- *Incremental Model Tracker sheets* (partially filled out from previous lessons)
- Wooden or plastic coffee stirrer OR straws OR an unbent paperclip (1)
- *Lesson 7 Assessment #1* (1)

Differentiated options for students for after the assessment:

- *Supplemental Investigation 7A* (1) and 6 wooden coffee stirrers
- *Supplemental Investigation 7B* (1) and a balloon. (If you use latex balloons, check for latex allergies first)
- A printout of this reading on how humans produce sounds:
<http://www.npr.org/templates/story/story.php?storyId=12908376>

Materials for the Whole Class

- The record, turntable, cone and needle apparatus from Lesson 1
- Video clips from lesson 2:
 - Video 1 - Michael Jackson Thriller Tracking the Needle on the Vinyl (show only 19:47 to 22:20)
 - https://www.youtube.com/watch?v=ova_qsOGRG4&t=1339s
 - Video 2 - path of the needle in a vinyl LP under the microscope
 - <https://www.youtube.com/watch?v=yUDclkJpMfo>
- A new video clip of a harp being played is at either of these URLs
 - <http://goo.gl/qEzNmZ>
 - <https://www.youtube.com/watch?v=emLXIFXieOk>
- *Lesson 7 Record Surface Student Handout* to project to the whole class
- Meter stick
- Computer with projector

Materials for the Teacher

- *Lesson 7 Student Assessment Key*
- *Lesson 7 Record Surface Student Handout* to project

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GETTING READY: TEACHER PREPARATION

Background Knowledge for the Teacher Only

This lesson is designed to help students review and restate the big ideas they have figured out in the previous lessons in many different ways, and put them together to explain the anchoring phenomenon.

It is also designed to help prepare them for an individual assessment on these ideas on the third day of this lesson. If you think it may be helpful for students to know you are planning on doing an individual assessment on the ideas that the class has figured out so far, and that today and tomorrow will help them review and extend their thinking about these ideas to get ready for that assessment, tell them this at the start of this lesson.

In this lesson, you are trying to support a “Putting Pieces Together” routine. All of these activities are designed to help students articulate and review these big ideas in multiple ways before the individual assessment: (a) talking with a partner about the ideas we figured out, (b) the attempt to predict how they apply to the needle and the record, (c) the manipulation of the wooden stick in two investigations using these ideas, and (d) the going public with these ideas by presenting them again around the image of the record surface are designed to help students articulate.

And by applying them back to the original anchoring phenomenon, you are helping students develop a sense of closure on at least the first part of their incremental model (what is going on at the sound source). Use the Lesson 7 - Student Assessment Key to provide students feedback after this lesson.

This lesson introduces the idea of a *forced vibration*. But no attempt is made to name this type of vibration, even though it is a different kind of vibration than the *natural vibration* of an object that is struck or plucked once. In high school, the distinction between natural frequencies of objects and objects that are forced to vibrate at non-natural frequencies because of repeated forces may be made.

The Framework for the NGSS refers to this DCI in the grade 9-12 band: Resonance is a phenomenon in which waves add up in phase in a structure, growing in amplitude due to energy input near the natural vibration frequency. Structures have particular frequencies at which they resonate. This phenomenon (e.g., waves in a stretched string, vibrating air in a pipe) is used in speech and in the design of all musical instruments. To prevent delving too far into these off grade band ideas, no attempt was made to explain the resonance phenomenon related to wind instruments or what is happening inside the sound hole on an acoustic guitar in Bend 1 of the storyline. All questions about what air is doing will be a big part of the investigations in the second bend of the storyline.

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The prompts early in the lesson ask students to recall what they have learned in prior lessons. Their responses provide evidence that students are making the important connections between sounds and vibrations that students will need to draw for this task. The sample student responses show evidence of only the DCI (objects vibrating at different amplitudes produce different volume sounds and when vibrating at different frequencies they produce different pitches). The last prompt likely probes students' ideas about structure and function, though without more explicit directions, it's unclear if instead it is supposed to probe cause and effect.

The prompts (and sample student responses) direct teachers to evaluate students' ideas in one dimension, but that can be useful as a formative assessment at the beginning of the lesson to make sure they have the tools they need to prepare for deeper sense-making. What is missing is clear communication to teachers about what they can use these probes to provide evidence of and what that evidence looks like if the students need more support.

DCIs CCCs

CONNECTION TO ASSESSMENT PURPOSE



Learning Plan: How can so many different sounds be coming from the needle and the record when you spin it?

**3 periods:
(40 min each)**

1. (5 min) Direct students to the bulleted questions at the top of their Student Activity Sheets. Ask them to discuss with a partner what we figured out so far that can help us answer some of the questions we had about louder vs. softer sounds, higher vs. lower pitch notes, and how the needle and the record player interact to produce sounds.^A

Listen for *student responses* such as:

- *The vibrations from sound sources change in amplitude (how far they move) when they produce louder vs. softer sounds.*
- *The vibrations from sound sources change in frequency (how fast they move back and forth) when they produce higher vs. lower pitch notes.*
- *The bumps and wavy shapes in the grooves make the needle vibrate as the record is spun.*

Sample student responses give teachers an idea of what to listen for – what is being assessed – but the sample responses are only at the proficient level and throughout the task multiple responses to one question vary in terms of what they imply is being evaluated. Some responses here are about the relationship between sounds and vibrations and one is about how grooves in the record cause vibrations. It isn't clear what teachers should listen for to know if students are not proficient, what different levels of proficiency sound like for the different dimensions that are being assessed, and how to attend to the students' needs based on their responses.

CONNECTION TO ASSESSMENT PURPOSE



Teacher Supports & Notes



Strategies for this Consensus Building Discussion

A Listen in to student discussions. Everything that students are saying and writing in this lesson is designed to help students review and restate the big ideas they have figured out in different ways as well as prepare them for an individual assessment on these ideas on the third day of this lesson.

If you think it may be helpful for students to know you are planning on doing an individual assessment on the ideas that the class has figured out so far and that today and tomorrow will help them review and extend their thinking about these ideas to get ready for that assessment, tell them at the start of this lesson.



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Through discussion, the teacher connects the students' ideas to the puzzling question they will investigate, which likely helps students more organically come to an understanding of WHY it is puzzling and interesting.

SCENARIOS

2. (5 min) Tell students, "I heard lots of key ideas being shared when I listened to your conversations about amplitude, frequency, and the structure of the grooves on the record related to the vibrations produced and the types of sounds that are made. But if differences in the volume of a sound and differences in the pitch of a sound are due to the differences in vibrations you described above, then wouldn't something have to be making the needle vibrate at different frequencies or deform with different amplitudes so that it produces different sounds? What might be forcing it to change its pattern of vibration?"

Have students consider this question and ways to investigate it further by individually answering questions 1 and 2 on their Student Activity Sheets.^B



Strategies for this Discussion

B Walk around and look at students' responses. Find some that identify the key ideas. Call on those students to help put the correct ideas on the table. It's OK to do this in this instance as it is designed as a "putting pieces together" lesson. We are trying to help students converge on and rearticulate the ideas they have already figured out in previous lessons.

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The sample student responses offer a few different examples of proficient responses, reminding teachers that there is not just one proficient response; there are many ways for students to show they are understanding the concepts. But it isn't clear enough what the connections are between the prompt, the student responses, and the NGSS dimensions being assessed.

CONNECTION TO ASSESSMENT PURPOSE

Students are offered a small degree of choice in this task. Here, they choose from two options the approach to examining data they prefer. Offering choice can help students find their own way to engage with a task, though here the choices are quite constrained.

EQUITY

3. (10 min) Ask a couple students to share out their answers with the whole class.

Listen for student responses such as:^C

- *The bumps, ridges, and wavy patterns of the grooves on the record are what is forcing it to change its pattern of vibration.*
- *We need to look at the record and the needle again to see if its vibrations are changing as it produces different sounds.*

Ask students which of the two data sources they want to look at for the needle and the record.^P

Suggested Prompt :

- We have two data sources we could look at that might provide the evidence we need: (a) the Michael Jackson video of the closeup of the needle on the record, and (b) our own homemade needle and record from the anchoring phenomenon. Let's pick only one of those to look at again to see if we can see differences in the frequency or amplitude of vibrations of the needle as it produces sounds.

Formative Assessment Opportunities

C Ask a few other students to restate the ideas that the students you called on shared by explaining in their own words what those ideas are. The first two periods of this lesson provide many opportunities for you to hear every student articulate ideas about (a) how frequency of vibration is related to pitch and how more and less frequent vibrations can be represented, and (b) how the amplitude of vibration is related to the distance of deformation of the sound source. Don't try to hear from every student in every discussion. Rather, make sure to hear from each one at some point across the two periods. You will have chances to hear and see them talk with partners, write on their sheets, work with manipulatives and go public with their ideas at many points. Make sure to prompt students who are working with partners, but not saying as much, to restate the ideas they are hearing from their peers, and ask them to try to show or explain those key ideas in a different way or build off of those ideas and add to them. This is at the heart of the arguing from evidence indicator that was used to build the lesson level.

Alternate Activities

D Any one of the data sources will be useful to look at. Push students to look at only one rather than look through all these data sources again. The goal in this lesson is to map existing ideas onto an old phenomenon, so any one of the sources of data should suffice.

The teacher materials provide some guidance as to the core ideas to listen for using student discussions as an informal formative assessment. These instructions support teachers by giving an explicit content goal, but they would be more helpful if they included guidance about supporting student progress with the other dimensions being evaluated in this task and if teachers were given more information about how evidence of progress with those dimensions might be revealed in different ways in response to different prompts.

CONNECTION TO ASSESSMENT PURPOSE

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The early questions in this set are useful as scaffolds; they bring students' attention to the ideas and observations that students need to be aware of to be prepared to respond to the making sense item at the end. For example, here students are being prompted to make observations about the movement of the needle and connecting that motion to different sounds, but these prompts vary in the degree to which they elicit evidence of students' progress with the lesson PE. For example, the first prompt evaluates students' observations about relevant features of the phenomenon, the others evaluate what students know about how different vibrations cause different sounds. The teacher materials provide possible responses, but teachers need to decide on the connections between each prompt and the dimensions being assessed, the prompts and the possible responses, and what it means if students do not provide these proficient responses. For example, the responses do not show if there are certain qualities of a proficient response that teachers should attend to (e.g., the DCI is clearly represented in the sample student responses, and other dimensions could be embedded but they aren't explicitly. Should students also be able to cite cause and effect when they talk about the relationship between type of vibration and sounds produced?). To help teachers track the many different dimensions that are included in the lesson learning target, these prompts would be more useful as formative assessments if they clearly indicated what to listen for as evidence of students' progress with using the multiple dimensions and guidance as to what to do if they are giving different responses than the samples provided.

DCIs

CCCs

SEPs

CONNECTION TO ASSESSMENT PURPOSE

Show students the data source they selected (of the two possible ones). Have students turn to Investigation 1 on their Student Activity Sheets as you show them the data source they selected again. Ask students questions about what they can claim from the data source they selected related to the questions we were wondering about.

Suggested Prompts:

- What differences in pitch or loudness do you hear?^E
- How must the motion of the needle be changing if it is producing different notes?
- How must the motion of the needle be changing if it is producing some sounds that are quiet and some that are loud?

Listen for *student responses* such as:

- *There were high notes and low notes, and there were quiet sounds and loud sounds.*
- *The needle must be vibrating at a greater frequency if it is producing higher pitch notes and lower frequency if it is producing lower pitch notes.*
- *The needle must be vibrating with a greater amplitude if it is producing a louder sound and lesser amplitude if it is producing a quieter sound.*



Alternate Activities

E If students pick the slow-motion video (microscopic view) of the needle on the record to look at, then skip the first prompt about differences in pitch or loudness and go straight to the next two questions about the motion of the needle.

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Giving the opportunity to expand the scale of the phenomenon, doing an experiment, and providing multiple opportunities to represent critical features supports all students in having access to sense-making about the phenomenon. Ideally, students would also be able to represent their ideas in a range of different ways. For example, students could be asked to here and/or in prompt 5 to draw a model of the relationship between the motion of the needle, the vibrations it produces, and the sounds that result from it. Overall, the task could make more use of the SEPs and CCCs to engage students' understanding of the DCI and to provide a variety of opportunities to gain insight into their ideas.

SEPs

CCCs

EQUITY

In this task students investigate vibrations related to sound in several different ways; here students scale up the vibrations in the needle and record by modeling the vibrations with a stick so they can observe it more easily. The multiple different representations of the same phenomenon have the potential to help students build a robust model of the concepts. It would be ideal if one of the investigations would draw on a sense other than sight to support students who are vision impaired, as well as students who would benefit from a very different type of representation.

EQUITY

4. (3 min) Tell students, “It seemed really difficult to see changes in frequency and amplitude in the vibration of the needle as clearly as when we had the motion detector, and we scaled up the size of the object that was vibrating. A lot of what we have been saying are predictions about how we think the needle’s vibrations must be changing as it moves through the patterns of bumps in the grooves of the record. If we could scale up the size of the needle just a bit as it interacts with the surface of the record, it might be easier for us to visualize the predicted motion of the needle.”

Hold up a coffee stirrer^F and ask students to talk with their partner about question 6 on their Student Activity Sheets as you pass out a coffee stirrer to each student.

5. (10 min) Pause student conversations and ask them to turn to the procedure for Investigation 2 on their Student Activity Sheets. Direct them to conduct this investigation with a partner. When they are done with Investigation 2, send one of the partners up to the front of the room to get two copies of the photograph of the surface of the record they looked at in an earlier lesson to use in Investigation 3 with the partner. Hold up the photograph to show them. Point out to students that Investigation 3 asks them to annotate and draw on this photograph, so they can prepare to share their findings with the whole group. Students should now conduct Investigation 3.



Alternate Activities

F If you don’t have coffee stirrers available, you could give students a straw or a paper clip.

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6. (5–7 min) Bring students back together and have them turn to the Making Sense section of their Student Activity Sheets. Emphasize that they should take the remaining time to plan with their partner about what they want to share with the whole class next time that would help support these two claims in that section:

- Different sections of grooves could force the needle to deform different distances, and therefore move back and forth at different amplitudes as the record is spun.
- Different sections of grooves could force the needle to move or bend back and forth at different frequencies as the record is spun.

Day 2

7. (4 min) Have students return to the Making Sense section of the Student Activity Sheets. Emphasize that they should take a few minutes to review with their partner about what they want to share with the whole class now that would help support the two claims in this section:

- Different sections of grooves could force the needle to deform different distances, and therefore move back and forth at different amplitudes as the record is spun.
- Different sections of grooves could force the needle to move or bend back and forth at different frequencies as the record is spun.

Project the L7 Record Surface Student Handout for students to reference in preparation for the next step.

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The preceding items serve as a review of previous learning about the relationship between different vibrations and different sounds to prime students to draw on those ideas as they respond to this sense-making task. This task draws on their multidimensional reasoning by asking students to identify evidence of patterns in the records that cause the different sounds. Students are providing some insight into their use of the practice of arguing from evidence by identifying evidence, though they do not construct an argument or provide and receive critiques of each other's claims, explanations, models or questions, so it just elicits a small piece of the claims for the SEP of this lesson. Similarly, the multiple CCCs claimed as a target for this lesson include patterns, structure and function (inferred), and cause and effect, and while those could be embedded in students' responses they aren't necessarily elicited. Students might be prepared to support their evidence with reasoning, and that reasoning might include evidence of the CCCs, but it will be up to the teacher to elicit and evaluate it.

DCIs SEPs CCCs **SENSE-MAKING**

It is clear based on the sample student responses that this item could elicit the DCI, some CCCs, and part of the SEP, but it is unclear how the task supports teachers in evaluating them. What if students are not providing these proficient responses? What would evidence of developing level patterns look like? Given that this 3-day lesson is really designed as a formative assessment to conclude bend 1, it would be helpful if it provided insight into what instructional steps teachers might take once they see evidence of common student struggles so they could be addressed before moving on to the next bend.

CONNECTION TO ASSESSMENT PURPOSE

8. (10 min) Ask for a student volunteer to come up to the board to show what parts of the L7 Record Surface Student Handout support the claims.^G Encourage students to use a meter stick^H as a representation of the needle to show how it would be vibrating differently as different parts of the record groove move under the needle. Encourage other students to link to, build off of, and add to the claims that they hear each student make to the class. Suggest that students call on other students to pass the meter stick to, so they are orchestrating the exchange of taking turns at presenting ideas in this discussion.

Listen for *student responses* such as:

- *Some changes in the bumps and ridges are really close together. Those are probably where the needle is forced to vibrate more frequently as it follows the pattern in that groove.*
- *Some places in the grooves are smoother or are gradually sloping. Those are probably where the needle is forced to vibrate less frequently as it follows the pattern in that groove.*
- *Some places in the grooves move very far to the left or right. Those are probably where the needle is forced to deform a larger distance, making it vibrate at a greater amplitude.*
- *Some places in the grooves move very little to the left or right. Those are probably where the needle is forced to deform a smaller distance, making it vibrate at a lesser amplitude.*

Classroom Artifact

G Having students go to the board to report out what they notice and encouraging them to call on other students who want to build off of the ideas they shared, is a powerful way to build a sense of community where students feel as if they are in the driver's seat of figuring out the science ideas. Examples shown here are from www.ngsx.org:



Additional Guidance

H The meter stick is a durable pointer to use here and serves as a sort of "talking stick" to pass from one presenter to the next. And it is more durable than the thinner piece of wood you used with the motion detector to measure vibrations.

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Throughout this task, students have had many opportunities to work through their ideas about the DCI using discourse and to practice identifying evidence that is critical to a phenomenon. They have provided insight to the teacher about their progress through small group and class discussion and through showing their evidence and talking about it in the class. But students haven't had opportunities to show their learning through different modalities, such as by using different practices like modeling, which could help them with sense-making and with communicating their progress. Now, at the end students are asked to add their ideas to their model tracker, but they aren't given more guidance as to what ideas. It seems that students are developing a model of a phenomenon that was introduced in lesson 1 (check), but for their models to provide explicit evidence of the many dimensions that are targeted for this lesson, and for teachers to use these models to evaluate their progress with those dimensions, this modeling task will need much more guidance as to what students should show in their models. The examples provided here describe concepts relevant to the DCI, but it's unclear how students are modeling these concepts or what the teacher should look for in their models to see evidence of these concepts.

EQUITY
CCCs
DCIs

SEPs
SENSE-MAKING

9. (7 min) Have students add these conclusions to their Incremental Model Tracker sheets.

Lesson	Date	Part of the Model	What We Figured Out That We Added to Our Model
7		A The needle and the record	<ul style="list-style-type: none"> Repeatedly applying a push or pull to an object over time and changing how much and/or how often that push or pull is applied can force the object to vibrate at different amplitudes and different frequencies. This is how the record forces the needle to produce quieter and louder sounds and high and low pitch sounds as it moves through different patterns in the grooves.

10. (5–7 min) Ask students questions about how spinning the record faster would affect the sounds produced in light of the claims they are making about the bumps and other places in the grooves forcing the needle to vibrate.

Suggested Prompts:

- If it is really that the patterns in these bumps are what is forcing the needle to vibrate at certain frequencies and amplitudes as the record is spun, then would spinning it faster affect how often these bumps hit the needle?
- How would that affect the frequency at which the needle is vibrating back and forth?
- How would that affect the pitch of the sounds produced?
- Wait, are you saying it would produce higher pitch sounds? We could test that. Should we test that?

Listen for *student responses* such as:

- *Spinning the record faster would make the bumps hit the needle more often.*
- *Spinning the record faster would make the needle vibrate back and forth more quickly.*
- *That would lead the needle to produce higher pitch sounds than if you spun the record more slowly.*
- *We should test that. Can I try and spin the record?*

Have students come up and stand around the record to work together to test this prediction.

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Middle School Unit: How Can We Sense So Many Different Sounds From a Distance?

11. (10–12 min) Emphasize that it seems like we have figured out a lot of stuff and that tomorrow you want to gauge students' ability to apply all of what we figured out to some additional sound-related phenomena, and so you will ask students to individually demonstrate how they can apply the ideas we figured out and the science practices we have been using. Point out that the time we spent the last two days really helped us identify the important pieces that we figured out so far, and we've reviewed many different ways we can show these ideas at work.

Remind students that the major ideas we have developed are in the Incremental Model Tracker sheets that they have been filling out, and these are the ideas they will need to apply on the assessment.

Encourage students to review these ideas with a partner by summarizing the evidence we collected and the arguments we made for each idea we had developed so far listed in each row of the Incremental Model Tracker sheets. This will help them prepare further for the individual assessment they will take tomorrow. Alternatively, encourage those students who are interested (or prefer) in taking their Incremental Model Tracker sheets with them to look through the DQB questions and identify some of the questions that they think we have developed answers to.¹

Day 3

12. (40 min) Remind students that we prepared for testing our ideas in a new context the last couple of days, and that today we should be ready to try to apply this understanding individually to some new phenomena. Pass out Lesson 7 — Assessment #1. As you are doing so, tell students that they will need to watch a video of a new phenomenon in order to answer the questions on the assessment before they get started, and that they will refer to what they saw in the video in their assessment.



Alternate Activities

If you think of other ways to have students review the big ideas they have figured out, try to incorporate the use of the Incremental Model Tracker sheets and/or the DQB questions. Integrating these artifacts into such reviews and assessment preparations, helps emphasize the role that the students play in the knowledge building process. Taking stock of questions answered on the DQB helps emphasize that those questions are the joint mission of the class, and the class is making progress on their joint mission. The students are deciding where they are going at each step in the larger mission. The Incremental Model Tracker emphasizes that the class is figuring out important science ideas and putting those ideas together piece by piece over time.

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Show students the video of someone playing a harp at either of these URLs. Replay the video again:

- <http://goo.gl/qEzNmZ>
- <https://www.youtube.com/watch?v=emLXIFXieOk>

Then have students individually complete Lesson 7—Assessment #1. Once students have completed this and turned this in, you may want to assign one of these supplemental resources to work on in class or as home-learning.^J

- Supplemental Investigation 7A
- Supplemental Investigation 7B

and/or

- A reading on how humans produce sounds:
<http://www.npr.org/templates/story/story.php?storyId=12908376> 2



Differentiation Strategies and Alternate Activities

J Providing students a choice to pick supplemental investigations or readings to learn more about, is one important way to differentiate instruction without compromising coherence of the storyline for the class. When you do this, the key is to make sure the structure of the investigation or information in the reading doesn't give away the punchline of upcoming lessons. Rather, it should extend the application of ideas the class figured out together. Make sure you provide students six wooden coffee stirrers if they want to conduct Supplemental Investigation 7A and provide a deflated balloon if they want to do Supplemental Investigation 7B. The activities in Investigation 7B make a lot of noise.

The NPR reading is redundant with Investigation 7B, but is an alternate resource to use in place of it if you prefer.

LESSON 7: HOW CAN SO MANY DIFFERENT SOUNDS BE COMING FROM THE NEEDLE AND THE RECORD WHEN YOU SPIN IT?

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ALIGNMENT WITH STANDARDS

Building Toward Target NGSS PE(s)

- **1-PS4-1.** Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.
- **4-PS4-1.** Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.
- **MS-PS4-1.** Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

Building Toward Common Core Standard(s) ELA

Comprehension and Collaboration:

CCSS.ELA-LITERACY.SL.6.1

Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.

- **CCSS.ELA-LITERACY.SL.6.1.B** Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed.
- **CCSS.ELA-LITERACY.SL.6.1.C** Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.

Building Toward Common Core Standard(s) MATH

Leveraging this standard:

CCSS.MATH.CONTENT.5.G.A.2

Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.

Building toward this standard:

CCSS.MATH.CONTENT.8.F.B.5

Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally.